

Electronic Supporting Information

Equatorial ligand plane perturbations lead to a spin-state change in an iron(III) porphyrin dimer

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Part 1: Experimental and computational methods

Experimental Section

Trans-1,2-bis[(chloro){5-(2,3,7,8,12,13,17,18-octaethylporphyrinyl)}iron(III)]ethane, **2**•Cl was prepared by modifying the literature methods.¹ Reagents and solvents were purchased from commercial sources and purified by standard procedures.

Synthesis of 2•perchlorate: 100 mg of **2**•Cl (0.079 mmol) was dissolved in 40 mL benzene and 33 mg (0.158 mmol) AgClO₄ in 2 mL acetonitrile was added to it and stirred at room temperature for 1 hour. The resulting solution was then evaporated to complete dryness. The solid was then dissolved in dichloromethane and the insoluble AgCl was filtered off. The filtrate thus obtained was then evaporated to dryness. The resulting solid was dissolved in minimum volume of dry CH₂Cl₂ and then carefully layered with benzene. On standing for 4–5 days, dark brown crystalline solid was formed which was collected by filtration and dried in vacuum. Yield: 90 mg (81%). **Caution!** Perchlorate salts are potentially explosive when heated or shocked. Handle them in milligram quantities with care. Yield: 91 mg, (77%). Anal. Calcd (found): C, 63.48 (63.70); H, 6.37 (6.55); N, 8.00 (8.15). UV-vis (dichloromethane) [λ_{\max} , nm (ϵ , M⁻¹ cm⁻¹): 394 (1.4 × 10⁵), 492 (3.1 × 10⁴), 545 (1.1 × 10⁴), 640 (5.1 × 10³). ¹H NMR (CDCl₃, 295 K): *meso*-H: -3.9, -15.7; -CH₃: 2.6, 2.7, 2.8; -CH₂: 16.0, 16.7, 17.2, 17.9, 18.1, 18.7, 19.2, 21.4; -CH(b): 33.6 ppm. Mössbauer: (α -Fe, 295 K): δ = 0.28 mm s⁻¹, ΔE_Q = 2.67 mm s⁻¹.

Synthesis of 2•picrate: 100 mg (0.079 mmol) of **2**•Cl was dissolved in 50 mL dichloromethane. 40 mg (0.174 mmol) 2,4,6-trinitrophenol in 2 mL dichloromethane was added to it and the was then refluxed for 30 min. The resulting solution was evaporated to complete dryness. The solid thus obtained was dissolved in minimum volume of dichloromethane, filtered to remove any solid residue and carefully layered with acetonitrile which was then kept for slow diffusion in air at room temperature. On standing for 5–6 days, dark brown crystalline solid was formed which was then collected by filtration, washed well with the mother liquor and dried in vacuum. Yield: 98 mg, (75%). Anal. Calcd (found): C, 62.32 (62.51); H, 5.59 (5.75); N, 11.83 (11.95). UV-vis (dichloromethane) [λ_{\max} , nm (ϵ , M⁻¹ cm⁻¹): 368 (1.9 × 10⁵), 516 (2.8 × 10⁴), 547 (2.2 × 10⁴), 653 (1.1 × 10⁴). EPR data: in solid (120 K), g_{\perp} = 6.02 and g_{\parallel} = 2.01; in dichloromethane (120 K), g_{\perp} =

6.05 and $g_{\parallel} = 1.97$. ^1H NMR (CDCl_3 , 295 K): *meso-H*: -22.0, -43.7; $-\text{CH}_3$: 5.9, 6.7, 7.7, 8.4; $-\text{CH}_2$: 35.5, 38.2, 39.1, 50.2, 51.5, 51.9, 53.2, 55.4; $-\text{CH}_2(\text{b})$: 109.5; m_t -*H*: 52.4 ppm. Mössbauer: (α -Fe, 295 K): $\delta = 0.30 \text{ mm s}^{-1}$, $\Delta E_Q = 0.58 \text{ mm s}^{-1}$.

Instrumentation

UV-vis spectra were recorded on a PerkinElmer UV/Vis spectrometer. ^{57}Fe Mössbauer spectra were recorded using a Wissel 1200 spectrometer and a proportional counter. $^{57}\text{Co}(\text{Rh})$ in a constant acceleration mode was used as the radioactive source. Isomer shifts (δ) are given related to α -iron foil at room temperature. Elemental (C, H, and N) analyses were performed on a PerkinElmer 2400II elemental analyzer. Electron paramagnetic resonance (EPR) spectra were obtained on a Bruker EMX EPR spectrometer. EPR spectral simulations were carried out using the Easy Spin software.² Magnetic susceptibility data were collected using a Quantum Design MPMS SQUID magnetometer over the temperature range 5 to 300 K. Data were collected in applied magnetic field of 0.2 T and corrected for diamagnetism using Pascal's constants. ^1H NMR spectra were recorded on a JEOL 500 MHz instrument. The spectra for paramagnetic molecules were recorded over a 100-kHz bandwidth with 64 K data points and a 5-ms 90° pulse. For a typical spectrum between 2000 and 3000 transients were accumulated with a 50- μs delay time. The residual ^1H resonances of the solvents were used as a secondary reference.

X-ray Structure Solution and Refinement

Single-crystal X-ray data were collected at 100 K on a Bruker SMART APEX CCD diffractometer equipped with CRYO Industries low temperature apparatus and intensity data were collected using graphite-monochromated $\text{MoK}\alpha$ radiation ($\lambda = 0.71073 \text{ \AA}$). The data integration and reduction were processed with SAINT software.³ An absorption correction was applied.⁴ The structure was solved by the direct method using SHELXS-97 and was refined on F2 by full-matrix least-squares technique using the SHELXL-2014 program package.⁵ Non-hydrogen atoms were refined anisotropically. In the refinement, hydrogens were treated as riding atoms using SHELXL default parameters. Crystal data and data collection parameters are given in Table S2.

Computational modeling

Following previously benchmarked methods,⁶ we utilized the OPBE⁷ density functional theory (DFT) method for geometry optimizations and frequencies in the gas phase for structures **1•X**, **2•X**, **1A•X**, **2A•X** with perchlorate and picrate as axial ligand (X). Thus, our initial calculations utilized an abbreviated system with all substituents of the two porphyrin residues set to hydrogen atoms (models **1A•X** and **2A•X** representing the ethane-bridged and ethene-bridged dimers, respectively). In addition, we studied the full models (models **1•X** and **2•X**, Scheme S1) for a selection of methods and spin states. All structures were geometry minimized without constraints using a double- ζ quality LACVP basis set on iron with electron core-potential and 6-31G* on the rest of the atoms: basis set BS1.⁸ All calculations are the result of a full geometry optimization on the overall $S = 1$ spin states with individual metal spin state $S = (3/2, -3/2)$ or $S = (5/2, -5/2)$ and a frequency calculation confirms the structures as local minima. In addition, the maximum (ferromagnetic) spin states were calculated as well, i.e. $S = (3/2, 3/2)$ and $S = (5/2, 5/2)$. All calculations for complexes **1•X**, **2•X**, **1A•X**, **2A•X** were run in Gaussian-09.⁹

To test the effect of spin state on structure, model size, energetics and environmental factors, we ran a number of exploratory calculations on models **1A•X** and **2A•X** with the BS1 basis set. Firstly, the effect of the density functional methods on the relative energies of the spin state ordering of the $S = (3/2, 3/2)$, $(3/2, 5/2)$ and $(5/2, 5/2)$ spin states was investigated through full geometry optimizations at the OPBE,⁷ PBE0,¹⁰ B98,¹¹ and BP86¹² functionals in the presence of an implicit solvent model mimicking water. In all cases the same spin-state ordering is obtained, although there is some fluctuation in the relative energies. In addition, inclusion of a solvent model does not affect the spin state energies with respect to the gas-phase either.

On some structures, the energetics was improved by single point calculations on all structures using the 6-311+G** basis set for all atoms: basis set BS2. Finally a single point using basis set def2-TZVP with the functional TPSSH¹³ was performed on all geometries: BS3.

References:

1. S. K. Ghosh, R. Patra and S. P. Rath, *Inorg. Chim. Acta*, 2010, **363**, 2791-2799.
2. S. Stoll, A. Schweiger, *J. Magn. Reson.*, **2006**, *178*, 42.
3. SAINT+, 6.02 ed., Bruker AXS, Madison, WI, **1999**.

4. G. M. Sheldrick, SADABS 2.0, **2000**.
5. G. M. Sheldrick, *SHELXL-2014: Program for Crystal Structure Refinement*; University of Göttingen: Göttingen, Germany, **2014**.
6. M. A. Sainna, D. Sil, D. Sahoo, B. Martin, S. P. Rath, P. Comba and S. P. de Visser, *Inorg. Chem.*, 2015, **54**, 1919.
7. J. P. Perdew, K. Burke and M. Ernzerhof, *Phys. Rev. Lett.*, 1997, **78**, 1396.
8. P. J. Hay and W. R. Wadt, *J. Chem. Phys.*, 1985, **82**, 270.
9. Gaussian 09, Revision D.01, M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov, J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J. Dannenberg, S. Dapprich, A. D. Daniels, Ö. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski and D. J. Fox, Gaussian, Inc., Wallingford CT, 2009.
10. C. Adamo and V. Barone, *J. Chem. Phys.*, 1999, **110**, 6158.
11. (a) A. D. Becke, *J. Chem. Phys.*, 1997, **107**, 8554; (b) H. L. Schmider and A. D. Becke, *J. Chem. Phys.*, 1998, **108**, 9624.
12. (a) A. D. Becke, *Phys. Rev. A*, 1988, **38**, 3098; (b) J. P. Perdew, *Phys. Rev. B*, 1986, **33**, 8822.
13. J. M. Tao, J. P. Perdew, V. N. Staroverov and G. E. Scuseria, *Phys. Rev. Lett.*, 2003, **91**, 146401.

Part 2: Experimental data

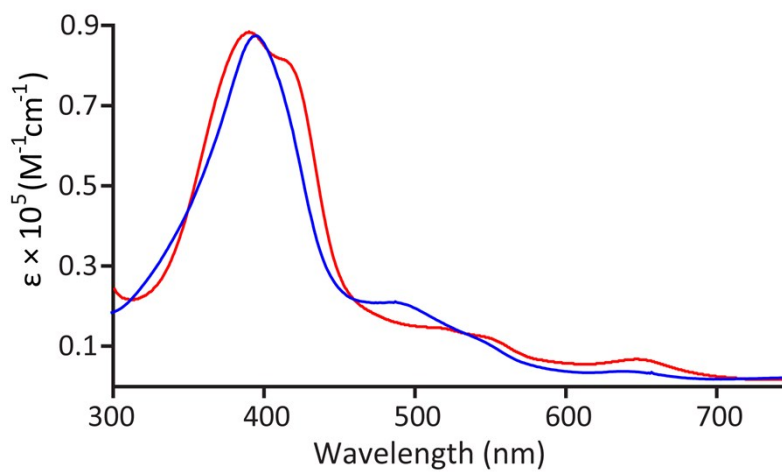


Fig. S1. UV-visible spectra (in dichloromethane at 295 K) of **1•perchlorate** (red line), and **2•perchlorate** (blue line).

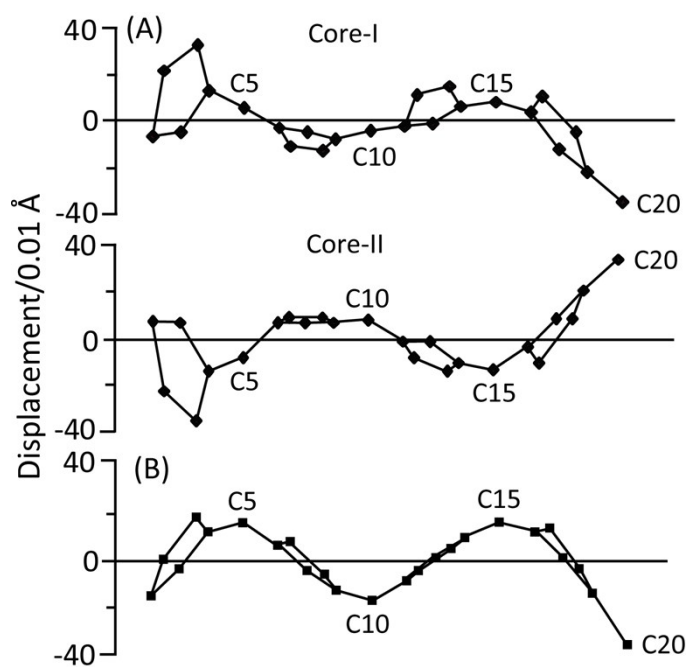


Fig. S2. Out-of-plane displacements (in units of 0.01 \AA) of the porphyrin core atoms of (A) **1•perchlorate**, and (B) **2•perchlorate** from the mean plane of the C_{20}N_4 porphyrinato core. The horizontal axes show the bond connectivity between atoms.

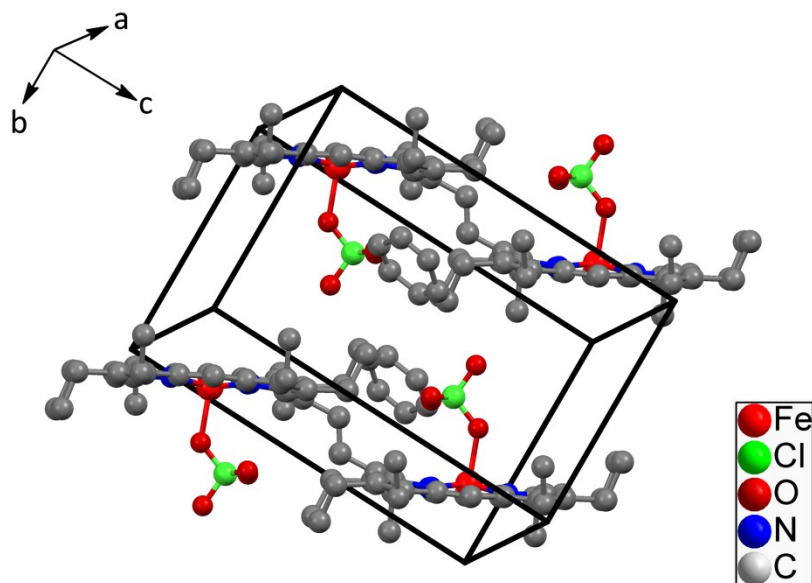


Fig. S3. Diagram illustrating the molecular packing of 2•perchlorate.2C₆H₆ at 100 K (hydrogen atoms have been omitted for clarity).

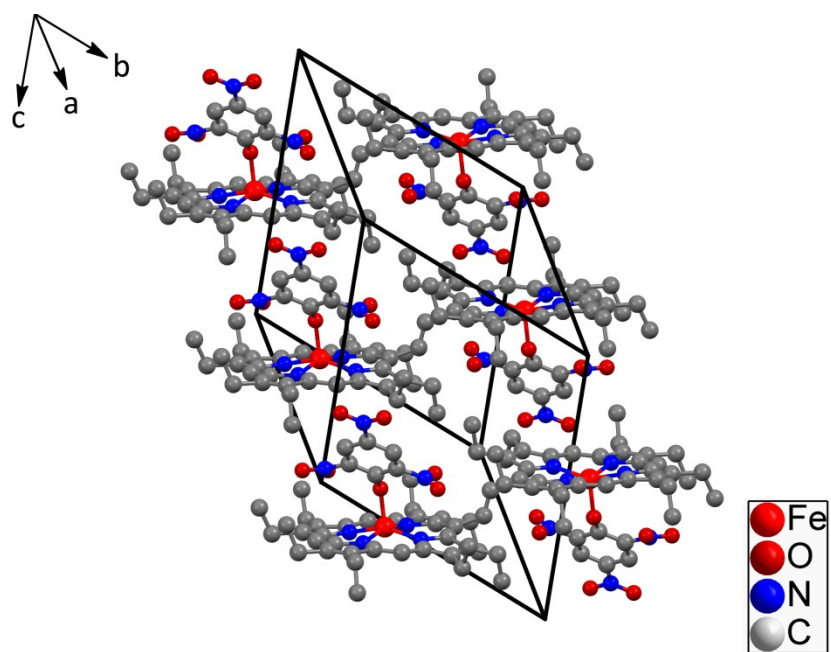


Fig. S4. Diagram illustrating the molecular packing of 2•picrate at 100 K (hydrogen atoms have been omitted for clarity).

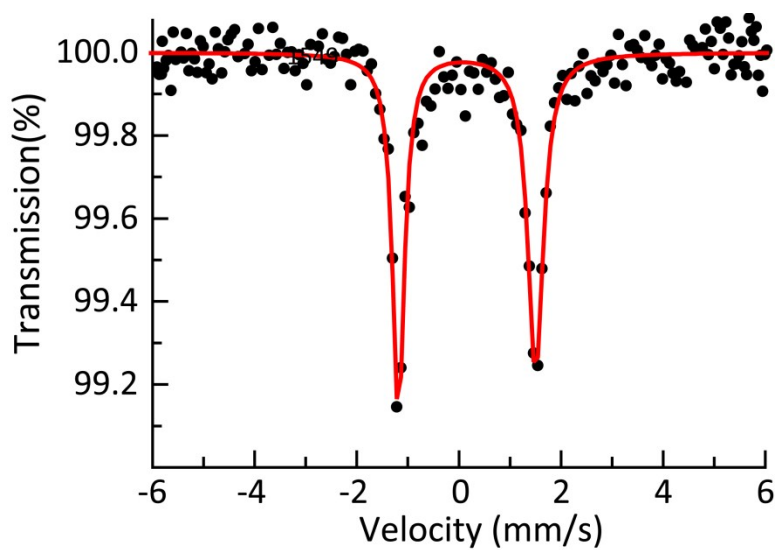


Fig. S5. Zero-field Mössbauer spectrum (at 100 K) of microcrystalline sample of **2**•perchlorate.

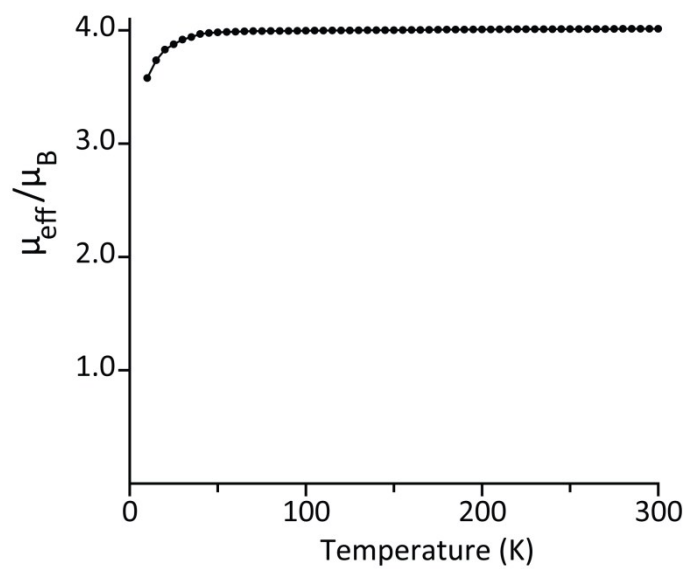


Fig. S6. Magnetic moment per iron center of crystalline sample of **2**•perchlorate as a function of temperature.

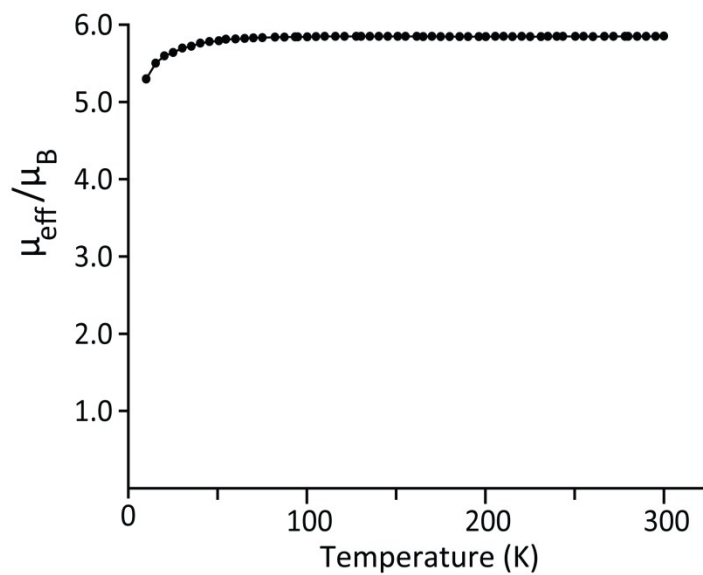


Fig. S7. Magnetic moment per iron center of crystalline sample of **2**•picrate as a function of temperature.

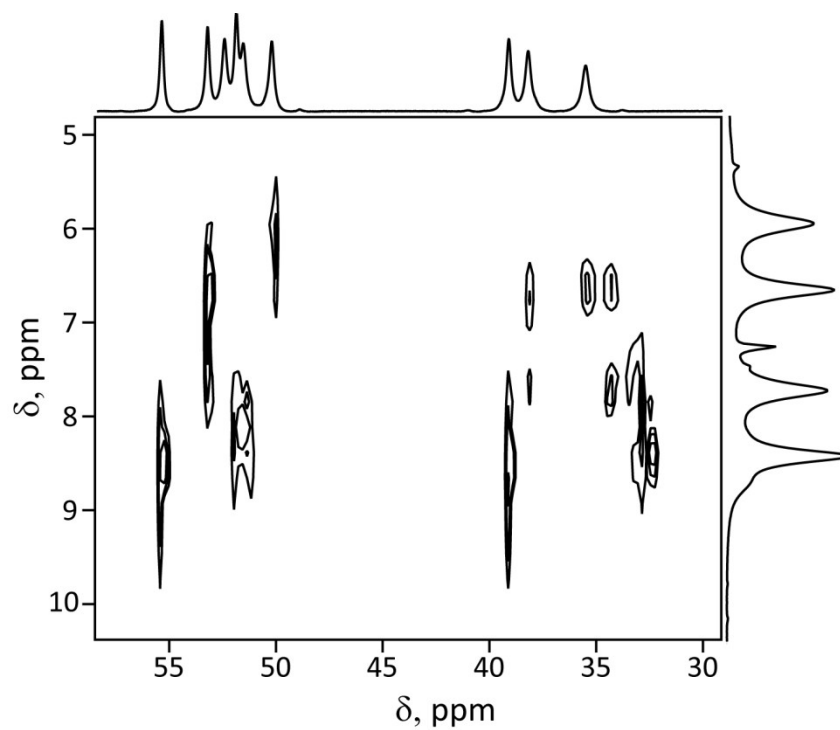


Fig. S8. ^1H - ^1H COSY (500 MHz) spectrum (in CDCl_3 at 295 K) of **2**•picrate.

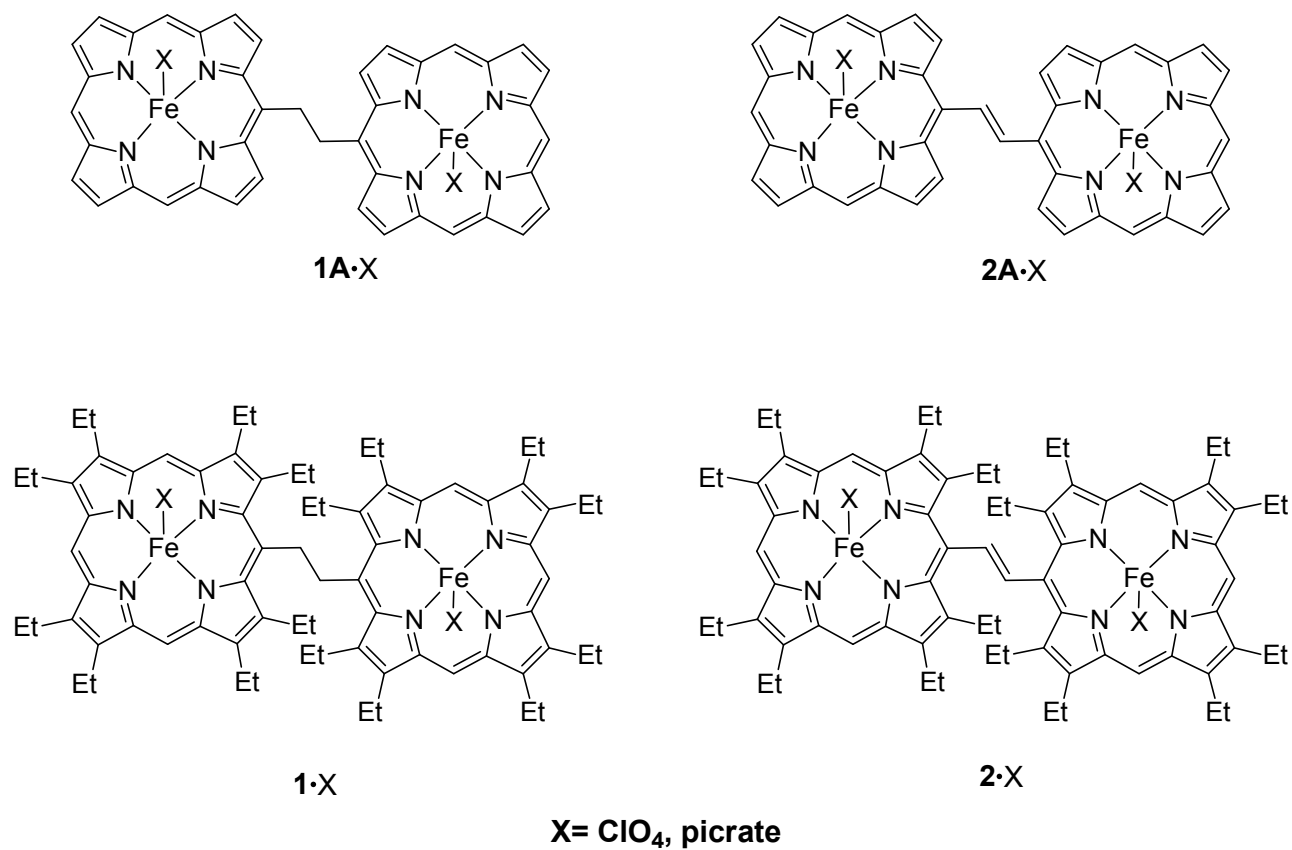
Table S1. Selected Bond Distances (Å) and Bond angles (°)

Bond distances	2 •perchlorate.2C ₆ H ₆	2 •picrate
Fe1–N1	1.989(4)	2.037(3)
Fe1–N2	2.000(4)	2.044(3)
Fe1–N3	2.003(4)	2.056(3)
Fe1–N4	2.004(4)	2.051(3)
Fe1–O1	2.056(4)	1.915(3)
N1–Fe1–N2	90.00(16)	89.01(13)
N1–Fe1–N3	165.36(16)	160.25(14)
N1–Fe1–N4	87.80(16)	86.89(13)
N2–Fe1–N3	88.08(16)	87.25(14)
N2–Fe1–N4	165.43(17)	155.81(14)
N3–Fe1–N4	90.42(16)	88.61(13)
N1–Fe1–O1	102.08(15)	102.76(12)
N2–Fe1–O1	95.56(15)	99.13(13)
N3–Fe1–O1	92.55(15)	96.98(13)
N4–Fe1–O1	98.99(15)	105.03(13)

Table S2. Crystallographic Data and Data Collection Parameters

	2•perchlorate.2C₆H₆	2•picrate
Formula	C ₈₆ H ₁₀₀ Cl ₂ Fe ₂ N ₈ O ₈	C ₈₆ H ₉₂ Fe ₂ N ₁₄ O ₁₄
<i>T</i> (K)	100(2)	100(2)
Formula weight	1556.33	1657.43
Crystal system	Triclinic	Triclinic
Space group	<i>P</i> -1	<i>P</i> -1
<i>a</i> , Å	10.8619(12)	12.077(5)
<i>b</i> , Å	13.5788(15)	13.443(5)
<i>c</i> , Å	15.2373(18)	14.103(5)
α , deg	64.626(2)	62.358(5)
β , deg	78.507(2)	74.156(5)
γ , deg	71.060(2)	72.733(5)
<i>V</i> , Å ³	1915.9(4)	1912.0(13)
<i>Z</i>	1	1
Radiation (λ , Å)	Mo K α (0.71073)	Mo K α (0.71073)
<i>d</i> _{calcd.} , g•cm ⁻³	1.349	1.439
<i>F</i> (000)	822	870
Crystal size (mm ³)	0.26 x 0.20 x 0.16 mm ³	0.18 x 0.14 x 0.10 mm ³
Theta range for data collection	1.724 to 25.497°	2.236 to 25.498°
μ , mm ⁻¹	0.512	0.458
No of unique data	7006	7129
Completeness to theta	98.4%	99.7%
No. of restraints	0	0
No. of params. refined	486	531
GOF on <i>F</i> ²	1.027	1.039
<i>R</i> 1 ^a [$> 2\sigma(I)$]	0.0691	0.0664
<i>R</i> 1 ^a (all data)	0.1106	0.1112
w <i>R</i> 2 ^b (all data)	0.1998	0.1770
Largest diff. peak and hole	1.118 and -0.738 eÅ ⁻³	1.271 and -0.384 eÅ ⁻³

$${}^a R1 = \frac{\sum ||F_o| - |F_c||}{\sum |F_o|} ; {}^b wR2 = \sqrt{\frac{\sum [w(F_o^2 - F_c^2)^2]}{\sum [w(F_o^2)^2]}}$$

Part 3: Computational Studies:**Scheme S1:** Models investigated in this work.

Part 3A: Small Model with Perchlorate Ligand

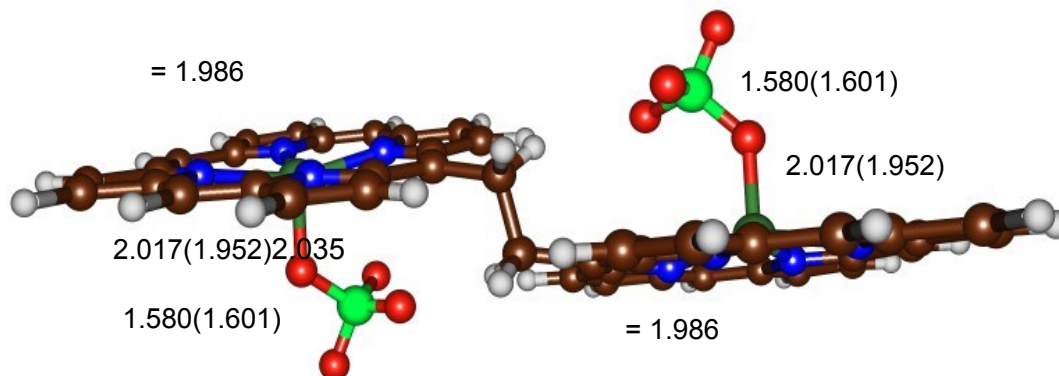


Fig. S9. Optimized geometries (distances in Å) in the gas phase of ${}^1\mathbf{1A}\cdot\text{perchlorate } \{3/2\}$ (${}^1\mathbf{1A}\cdot\text{perchlorate } \{5/2\}$) as obtained at UOPBE/BS1 in Gaussian.

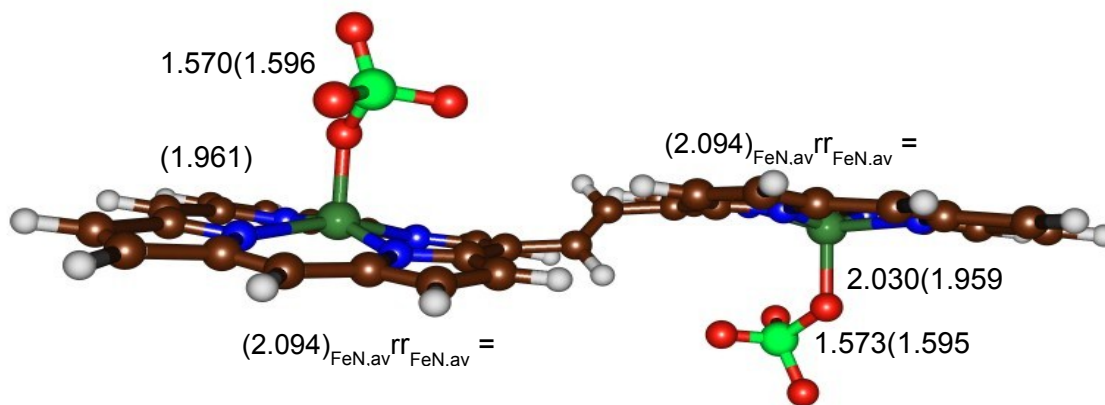


Fig. S10. Optimized geometries (distances in Å) of ${}^1\mathbf{2A}\cdot\text{perchlorate } \{3/2\}$ (${}^1\mathbf{2A}\cdot\text{perchlorate } \{5/2\}$) as obtained at UOPBE/BS1 in Gaussian.

Table S3: Absolute [in au] and relative [in kcal mol⁻¹] energies of optimized spin state structures as calculated at OPBE/BS1, OPBE/BS2, and TPSSh/BS3. Data obtained in the gas-phase.

(a) OPBE/BS1 data:

BS1	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹ 1A•perchlorate {3/2}	-3822.009934	-3821.395840	-3821.485220	0.00	0.00	0.28
¹ 1A•perchlorate {5/2}	-3822.005089	-3821.394429	-3821.485669	3.04	0.89	0.00
¹ 2A•perchlorate {3/2}	-3820.784618	-3820.195120	-3820.284860	0.00	0.00	1.04
¹ 2A•perchlorate {5/2}	-3820.780653	-3820.194476	-3820.286520	2.49	0.40	0.00

(b) OPBE/BS2 data:

BS2	E [au]	ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹ 1A•perchlorate {3/2}	-6103.788366	-6103.174272	-6103.263652	0.00	0.00	0.00
¹ 1A•perchlorate {5/2}	-6103.782618	-6103.171958	-6103.263198	3.61	1.45	0.28
¹ 2A•perchlorate {3/2}	-6102.563591	-6101.974093	-6102.063833	0.00	0.00	0.00
¹ 2A•perchlorate {5/2}	-6102.557402	-6101.971225	-6102.063269	3.88	1.80	0.35

(c) TPSSh/BS3 data:

BS3	E [au]	ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹ 1A•perchlorate {3/2}	-6104.703442	-6104.089348	-6104.178728	0.00	0.00	0.00
¹ 1A•perchlorate {5/2}	-6104.680502	-6104.069842	-6104.161082	14.39	12.24	11.07
¹ 2A•perchlorate {3/2}	-6103.476286	-6102.886789	-6102.976529	0.00	0.00	0.00
¹ 2A•perchlorate {5/2}	-6103.451814	-6102.865637	-6102.957681	15.36	13.27	11.83

Table S4: Absolute [in au] and relative [in kcal mol⁻¹] energies of optimized spin state structures as calculated at OPBE/BS1, PBE0/BS1, B98/BS1, and BP86/BS1. Data obtained with a dielectric constant mimicking water included.

OPBE/BS1	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹¹ 1A•perchlorate	-3822.04828	-3821.43825	-3821.53237	8.40	6.17	5.67
⁹ 1A•perchlorate	-3822.05492	-3821.44278	-3821.53472	4.23	3.33	4.20
⁷ 1A•perchlorate	-3822.06166	-3821.44808	-3821.54140	0.00	0.00	0.00
¹¹ 2A•perchlorate	-3820.82511	-3820.23890	-3820.32982	8.26	6.40	6.86
⁹ 2A•perchlorate	-3820.83222	-3820.24432	-3820.33541	3.80	2.99	3.35
⁷ 2A•perchlorate	-3820.83827	-3820.24909	-3820.34076	0.00	0.00	0.00

PBE0/BS1	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹¹ 1A•perchlorate	-3819.30867	-3818.68249	-3818.77351	7.86	5.68	4.19
⁹ 1A•perchlorate	-3819.31505	-3818.68707	-3818.77668	3.86	2.81	2.19
⁷ 1A•perchlorate	-3819.32121	-3818.69155	-3818.78018	0.00	0.00	0.00
¹¹ 2A•perchlorate	-3818.08520	-3817.48352	-3817.57443	7.61	5.53	3.98
⁹ 2A•perchlorate	-3818.09155	-3817.48819	-3817.57629	3.62	2.60	2.81
⁷ 2A•perchlorate	-3818.09732	-3817.49233	-3817.58077	0.00	0.00	0.00

B98/BS1	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹¹ 1A•perchlorate	-3821.44193	-3820.82842	-3820.92004	20.60	15.87	14.85
⁹ 1A•perchlorate	-3821.45838	-3820.84190	-3820.93138	10.28	7.41	7.73
⁷ 1A•perchlorate	-3821.47476	-3820.85370	-3820.94370	0.00	0.00	0.00
¹¹ 2A•perchlorate	-3820.21698	-3819.62535	-3819.71385	19.27	16.11	16.38
⁹ 2A•perchlorate	-3820.23443	-3819.64138	-3819.73100	8.32	6.05	5.62
⁷ 2A•perchlorate	-3820.24769	-3819.65102	-3819.73996	0.00	0.00	0.00

BP86/BS1	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹¹ 1A •perchlorate	-3822.94790	-3822.35107	-3822.44766	30.40	27.32	24.65
⁹ 1A •perchlorate	-3822.97196	-3822.37225	-3822.46492	15.30	14.03	13.81
⁷ 1A •perchlorate	-3822.99634	-3822.39461	-3822.48693	0.00	0.00	0.00
¹¹ 2A •perchlorate	-3821.72747	-3821.15386	-3821.24940	29.89	27.25	24.81
⁹ 2A •perchlorate	-3821.75172	-3821.17590	-3821.26858	14.67	13.42	12.77
⁷ 2A •perchlorate	-3821.77511	-3821.19729	-3821.28893	0.00	0.00	0.00

Part 3B: Small Model with picrate Ligand

Table S5: Absolute [in au] and relative [in kcal mol⁻¹] energies of optimized spin state structures as calculated at OPBE/BS1, and picrate ligand.

BS1	E [au]	ZPE [au]	G [au]	ΔE	$\Delta E + ZPE$	ΔG
¹¹ 1A •picrate	-4140.825627	0.777478	-4140.166590	0.58	-1.38	-3.24
¹ 1A •picrate{3/2}	-4140.826546	0.780600	-4140.161432	0.00	0.00	0.00
⁷ 1A •picrate	-4140.828906	0.780389	-4140.161771	-1.48	-1.61	-0.21
¹¹ 2A •picrate	-4139.607226	0.753557	-4138.970051	0.22	-1.56	-4.60
¹ 2A •picrate{3/2}	-4139.607581	0.756406	-4138.962716	0.00	0.00	0.00
⁷ 2A •picrate	-4139.608106	0.756675	-4138.965073	-0.33	-0.16	-1.48

Part 3C: Large Model with perchlorate Ligand

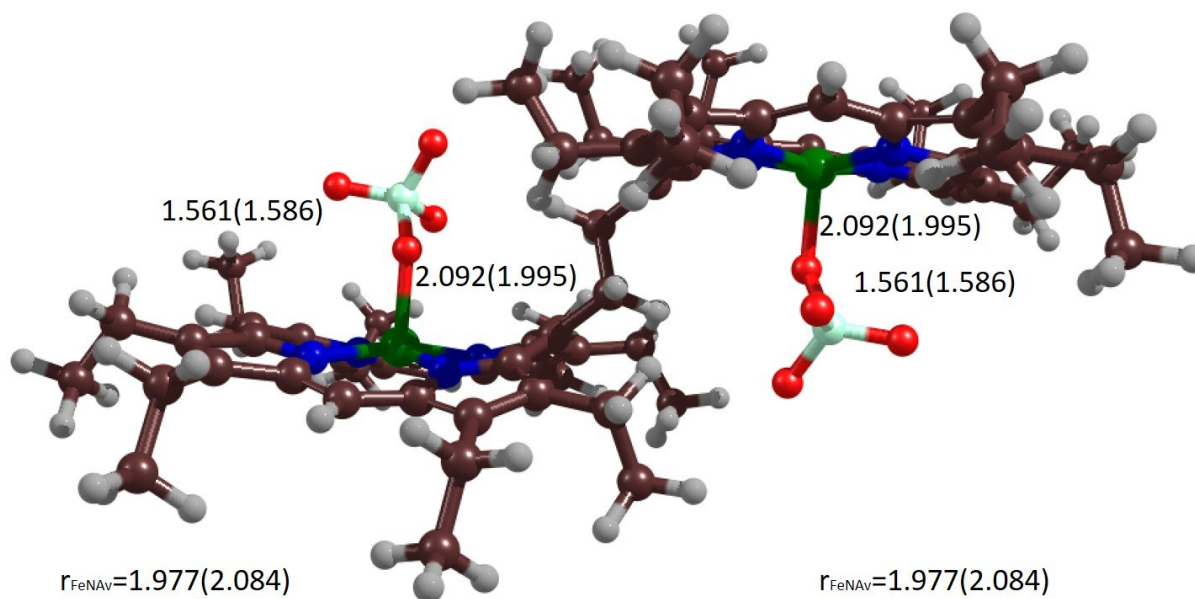


Fig. S11: Optimized geometries (distances in Å) of $^1\mathbf{1}\cdot\text{perchlorate } \{3/2\}$ ($^1\mathbf{1}\cdot\text{perchlorate } \{5/2\}$) as obtained at UOPBE/BS1 in Gaussian.

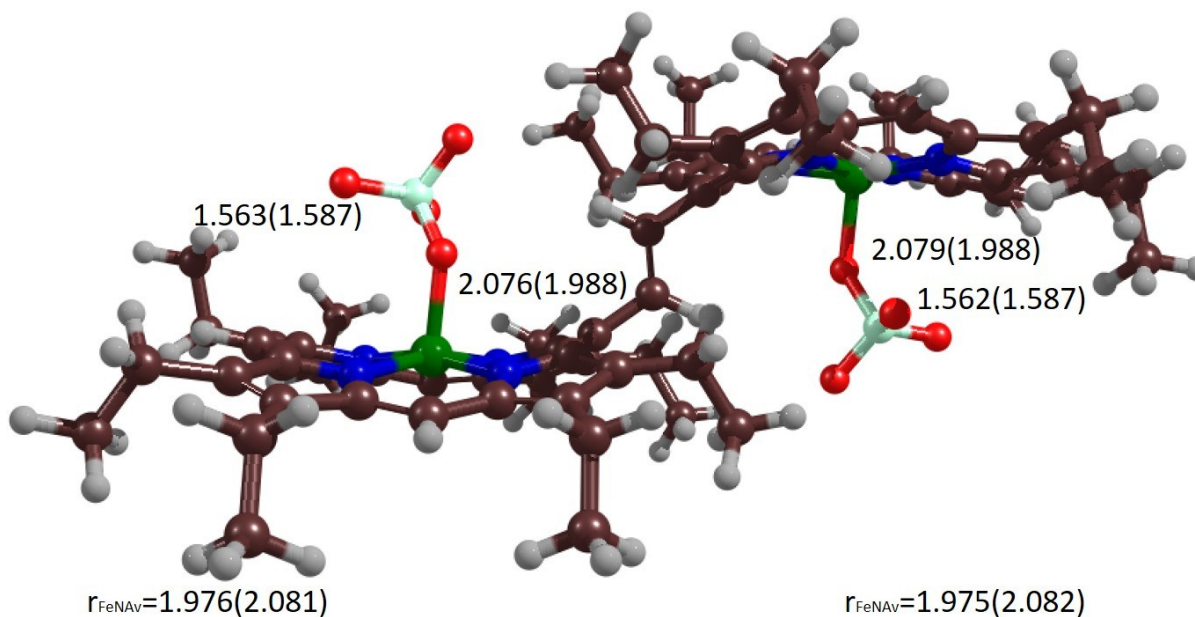


Fig. S12: Optimized geometries (distances in Å) of $^1\mathbf{2}\cdot\text{perchlorate } \{3/2\}$ ($^1\mathbf{2}\cdot\text{perchlorate } \{5/2\}$) as obtained at UOPBE/BS1 in Gaussian.

Table S6: Absolute [in au] and relative [in kcal mol⁻¹] energies of optimized spin state structures as calculated at OPBE/BS1, OPBE/BS2, and TPSSh/BS3.

BS1	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹ 1•perchlorate {3/2}	-5079.50983	-5077.99619	-5078.14247	0.00	0.00	0.00
¹ 1•perchlorate {5/2}	-5079.49975	-5077.98921	-5078.13594	6.32	4.38	4.10
¹ 2•perchlorate {3/2}	-5078.29344	-5076.80411	-5076.94707	0.00	0.00	0.00
¹ 2•perchlorate {5/2}	-5078.28304	-5076.79778	-5076.94412	6.53	3.98	1.85

BS2	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹ 1•perchlorate {3/2}	-7361.683904	-7360.170266	-7360.316544	0.00	0.00	0.00
¹ 1•perchlorate {5/2}	-7361.673236	-7360.162690	-7360.309422	6.69	4.75	4.47
¹ 2•perchlorate {3/2}	-7360.466726	-7358.977405	-7359.120364	0.00	0.00	0.00
¹ 2•perchlorate {5/2}	-7360.456147	-7358.970889	-7359.117234	6.64	4.09	1.96

BS3	E [au]	E+ZPE [au]	G [au]	ΔE	$\Delta E+ZPE$	ΔG
¹ 1•perchlorate {3/2}	-7363.289879	-7361.776241	-7361.922519	0.00	0.00	0.00
¹ 1•perchlorate {5/2}	-7363.260224	-7361.749679	-7361.896411	18.61	16.67	16.38
¹ 2•perchlorate {3/2}	-7362.070036	-7360.580715	-7360.723674	0.00	0.00	0.00
¹ 2•perchlorate {5/2}	-7362.041724	-7360.556466	-7360.702811	17.77	15.22	13.09

Part 3D: Large Model with picrate Ligand

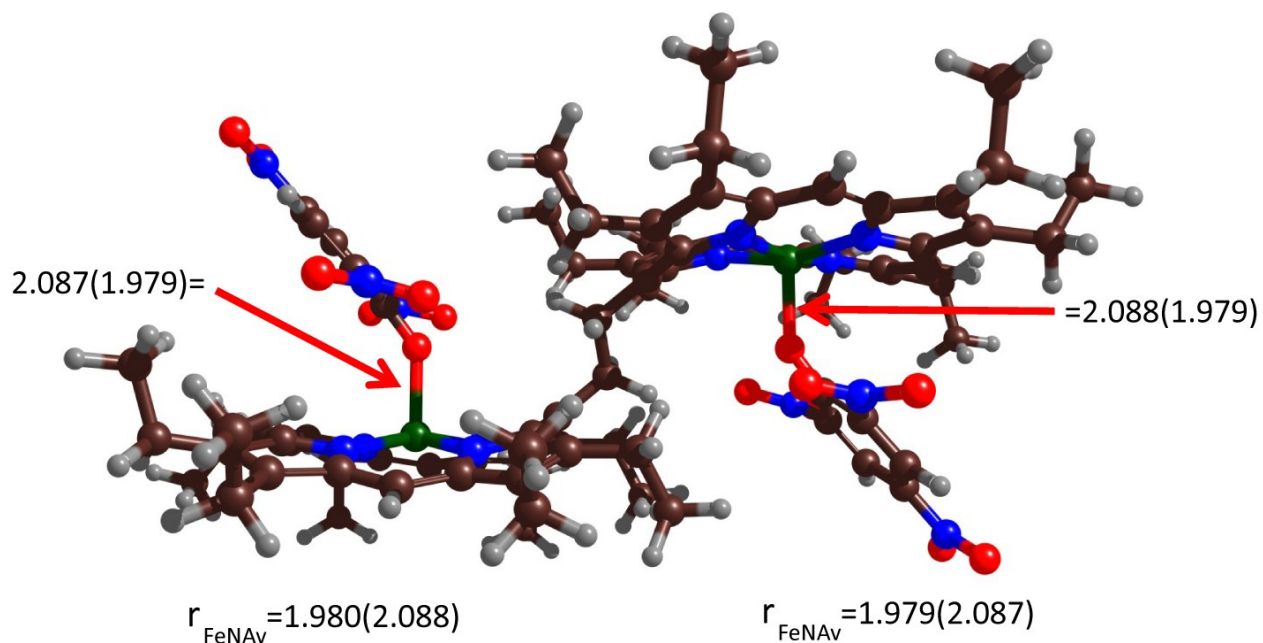


Fig. S13: Optimized geometries (distances in Å) of ${}^71\bullet$ picrate (${}^{11}\bullet$ picrate) as obtained at UOPBE/BS1 in Gaussian.

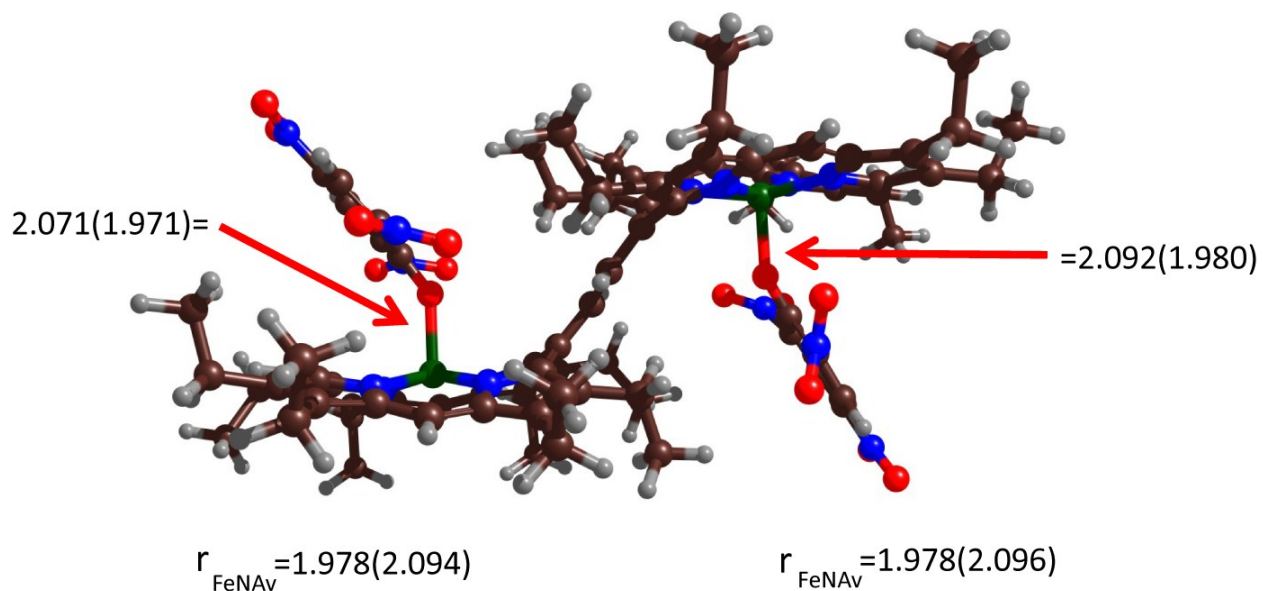


Fig. S14: Optimized geometries (distances in Å) of ${}^72\bullet$ picrate (${}^{12}\bullet$ picrate) as obtained at UOPBE/BS1 in Gaussian

Table S7: Absolute [in au] and relative [in kcal mol⁻¹] energies of optimized spin state structures as calculated at OPBE/BS1 with picrate axial ligand.

BS1	E [au]	E+ZPE [au]	G [au]	ΔE	ΔE+ZPE	ΔG
¹¹ 1•picrate	-5398.321982	1.677826	-5396.817277	5.51	3.61	0.11
¹ 1•picrate{3/2}	-5398.330768	1.680855	-5396.817454	0.00	0.00	0.00
⁷ 1•picrate	-5398.330681	1.681025	-5396.815255	0.05	0.16	1.38
¹¹ 2•picrate	-5397.112488	1.652628	-5395.632828	3.59	1.44	-1.31
¹ 2•picrate{3/2}	-5397.118212	1.656059	-5395.630740	0.00	0.00	0.00
⁷ 2•picrate	-5397.118031	1.656289	-5395.631338	0.11	0.26	-0.38

Part 4: Computation: Cartesian coordinates

Structure ¹1A•perchlorate {3/2}

Fe	5.879669000	4.638006000	1.925337000	H	9.867147000	4.895477000	-1.429749000
Fe	6.810756000	-4.440136000	-2.107909000	H	8.730648000	2.501900000	-1.905216000
Cl	7.428969000	2.323777000	3.826597000	C	10.021464000	-1.906935000	-3.234369000
N	4.739160000	3.198727000	1.165020000	H	4.033956000	0.365051000	-0.485725000
N	4.343960000	5.278728000	3.053695000	Cl	3.940599000	-2.918306000	-2.897483000
N	6.790817000	6.387315000	2.319291000	C	8.481843000	-5.076054000	-4.570052000
N	7.151302000	4.302527000	0.430205000	C	8.482987000	-5.911814000	-5.737805000
O	6.798598000	3.722721000	3.494183000	C	7.390520000	-6.727674000	-5.636737000
O	6.383072000	1.303497000	3.633924000	C	6.762336000	-6.421566000	-4.382446000
O	8.561813000	2.117890000	2.911043000	C	5.706460000	-7.141961000	-3.837612000
C	5.126230000	2.172841000	0.320817000	H	5.254042000	-7.926566000	-4.440603000
C	4.036603000	1.250313000	0.139694000	C	5.294546000	-7.008127000	-2.518578000
C	2.982160000	1.733066000	0.859257000	C	4.418166000	-7.924552000	-1.846020000
C	3.434619000	2.920403000	1.514149000	C	4.392736000	-7.551274000	-0.531037000
C	2.655820000	3.624973000	2.420922000	C	5.207794000	-6.375152000	-0.420536000
H	1.644035000	3.265676000	2.598386000	C	5.351793000	-5.622006000	0.735090000
C	3.100944000	4.704166000	3.167375000	H	4.869673000	-5.980961000	1.642279000
C	2.339682000	5.339061000	4.205553000	C	5.962962000	-4.375428000	0.780013000
C	3.149302000	6.293753000	4.753041000	C	5.890596000	-3.498716000	1.908490000
C	4.383051000	6.258261000	4.018719000	C	6.427793000	-2.304373000	1.519228000
C	5.427680000	7.150670000	4.210855000	C	6.897815000	-2.476144000	0.169277000
H	5.340102000	7.877228000	5.016238000	C	7.649010000	-1.528641000	-0.544958000
C	6.532188000	7.231153000	3.374294000	C	7.656367000	-0.087423000	-0.104043000
C	7.519674000	8.271080000	3.443820000	H	7.294437000	0.001651000	0.921662000
C	8.374653000	8.070255000	2.396963000	H	8.671359000	0.328463000	-0.085829000
C	7.922228000	6.888179000	1.720482000	C	9.372262000	-4.036299000	-4.344627000
C	8.571832000	6.310150000	0.641419000	H	10.173585000	-3.885317000	-5.065659000
H	9.456937000	6.810361000	0.253234000	O	5.454478000	-3.298823000	-3.097217000
C	8.217681000	5.097080000	0.067664000	O	3.911525000	-1.446720000	-2.837735000
C	8.988746000	4.464885000	-0.957264000	O	3.464540000	-3.524861000	-1.647218000
C	8.413563000	3.247586000	-1.185378000	O	3.236864000	-3.438994000	-4.073746000
C	7.264291000	3.154103000	-0.328071000	H	9.216077000	-5.859722000	-6.538129000
C	6.364761000	2.076701000	-0.332557000	H	7.050275000	-7.490689000	-6.331370000
C	6.748432000	0.788635000	-1.019082000	H	3.913295000	-8.761091000	-2.321113000
H	7.258025000	0.978384000	-1.971068000	H	3.851811000	-8.010894000	0.291505000
H	5.859638000	0.212422000	-1.286134000	H	5.454864000	-3.754077000	2.870307000
O	7.851896000	2.426325000	5.225795000	H	6.525341000	-1.413545000	2.129964000
H	1.984185000	1.313373000	0.948288000	H	10.867085000	-1.666894000	-3.873043000
H	1.324082000	5.070815000	4.483123000	H	9.812417000	-0.184552000	-1.884410000
H	2.933357000	6.978917000	5.568198000	C	8.394696000	-1.917800000	-1.671345000
H	7.536052000	9.060327000	4.190392000	C	9.472641000	-1.152625000	-2.234592000
				H	9.244387000	8.655053000	2.110452000
				N	6.606676000	-3.755284000	-0.266361000
				N	5.760085000	-6.056578000	-1.638749000

N	7.431034000	-5.402456000	-3.746275000
N	8.274170000	-3.115417000	-2.342491000
C	9.239172000	-3.102505000	-3.323331000

Structure ¹A•perchlorate {5/2}

Fe	6.038630000	4.574587000	2.217414000
Fe	6.573529000	-4.415701000	-2.335179000
Cl	7.437079000	2.217243000	4.074352000
N	4.793264000	3.190393000	1.291268000
N	4.342997000	5.390143000	3.158514000
N	6.875910000	6.493765000	2.446214000
N	7.289818000	4.300219000	0.569398000
O	6.886391000	3.676153000	3.738188000
O	6.303094000	1.293545000	3.945581000
O	8.498366000	1.931341000	3.102332000
C	5.164160000	2.202669000	0.402140000
C	4.068972000	1.276413000	0.231391000
C	3.039306000	1.724493000	1.009596000
C	3.500685000	2.908906000	1.673584000
C	2.733679000	3.634673000	2.585719000
H	1.730789000	3.257318000	2.781783000
C	3.121659000	4.778965000	3.281723000
C	2.307929000	5.480053000	4.241255000
C	3.060664000	6.523451000	4.705536000
C	4.323465000	6.463227000	4.014381000
C	5.354780000	7.393732000	4.149001000
H	5.205766000	8.199462000	4.866780000
C	6.531351000	7.421535000	3.397315000
C	7.526164000	8.461193000	3.459738000
C	8.470023000	8.159584000	2.516340000
C	8.053988000	6.929273000	1.894653000
C	8.748707000	6.269693000	0.881169000
H	9.671603000	6.7344457000	0.536323000
C	8.393972000	5.065623000	0.271001000
C	9.168395000	4.431604000	-0.757308000
C	8.532316000	3.261421000	-1.064245000
C	7.355078000	3.184648000	-0.234382000
C	6.401082000	2.143279000	-0.278049000
C	6.739144000	0.891353000	-1.053310000
H	7.215392000	1.133529000	-2.011080000
H	5.829990000	0.348461000	-1.320150000
O	7.930865000	2.326853000	5.445318000
H	2.050397000	1.287841000	1.119082000
H	1.294732000	5.205112000	4.521969000
H	2.785354000	7.275755000	5.439928000
H	7.495533000	9.316014000	4.130118000
H	10.080954000	4.831121000	-1.191402000
H	8.834784000	2.539513000	-1.814469000
C	9.791788000	-1.791161000	-3.559094000
H	4.045590000	0.405072000	-0.413195000
Cl	3.756057000	-2.934239000	-3.129892000
C	8.474339000	-5.184505000	-4.690002000
C	8.619637000	-6.144241000	-5.754144000
C	7.700435000	-7.130893000	-5.521818000
C	7.015410000	-6.779786000	-4.304560000
C	6.063834000	-7.576751000	-3.662852000
H	5.781407000	-8.506012000	-4.155952000
C	5.511398000	-7.331681000	-2.404885000
C	4.671092000	-8.248003000	-1.677030000
C	4.440409000	-7.682873000	-0.453051000
C	5.119238000	-6.412346000	-0.448760000
C	5.109182000	-5.499036000	0.604364000
H	4.557159000	-5.785944000	1.498536000
C	5.697805000	-4.233233000	0.618441000
C	5.585991000	-3.311147000	1.711352000
C	6.220699000	-2.161693000	1.331410000
C	6.755903000	-2.390716000	0.009501000
C	7.567816000	-1.488591000	-0.714568000
C	7.667336000	-0.060080000	-0.234631000
H	7.393466000	0.009362000	0.819995000
H	8.699910000	0.306188000	-0.281525000
C	9.207069000	-4.004128000	-4.568652000
H	9.959784000	-3.812801000	-5.332757000
O	5.174279000	-3.597024000	-3.439604000
O	4.027272000	-1.516269000	-2.859671000
O	3.190730000	-3.626473000	-1.968224000
O	2.982038000	-3.139734000	-4.352535000
H	9.329893000	-6.068007000	-6.573188000

H	7.512382000	-8.024916000	-6.110388000
H	4.320400000	-9.206279000	-2.050879000
H	3.858402000	-8.083428000	0.372598000
H	5.081296000	-3.510991000	2.652610000
H	6.323204000	-1.265033000	1.932520000
H	10.583745000	-1.518982000	-4.251708000
H	9.643736000	-0.084904000	-2.189642000
C	8.277005000	-1.857894000	-1.881128000
C	9.301138000	-1.061381000	-2.512250000
H	9.368216000	8.716377000	2.262842000
N	6.416564000	-3.662095000	-0.406553000
N	5.760660000	-6.215104000	-1.644761000
N	7.491725000	-5.586889000	-3.821260000
N	8.147252000	-3.050437000	-2.553757000
C	9.051449000	-3.021242000	-3.588214000

Structure ¹2A•perchlorate {3/2}

Fe	5.976308000	4.762610000	1.974025000
Cl	8.592738000	3.234615000	3.334165000
N	4.692561000	3.286709000	1.641628000
N	4.767599000	5.481791000	3.382309000
N	6.910064000	6.514890000	1.970121000
N	6.802385000	4.310271000	0.229079000
O	7.108843000	3.778036000	3.321577000
O	8.567651000	1.925055000	2.666128000
O	9.436746000	4.200631000	2.618795000
C	4.921014000	2.171775000	0.876734000
C	3.774157000	1.305712000	0.907355000
C	2.846768000	1.908129000	1.713703000
C	3.445041000	3.113160000	2.203077000
C	2.894392000	3.914016000	3.195470000
H	1.919093000	3.633845000	3.589223000
C	3.555962000	4.979409000	3.792682000
C	3.098679000	5.671606000	4.964196000
C	4.068982000	6.579721000	5.288147000
C	5.085478000	6.474515000	4.279901000
C	6.163136000	7.343061000	4.153484000
H	6.312403000	8.092972000	4.927861000
C	6.967438000	7.399919000	3.021835000
C	7.882982000	8.466147000	2.727763000
C	8.348135000	8.246414000	1.460842000
C	7.757090000	7.017518000	1.012506000
C	8.060661000	6.386576000	-0.186214000
H	8.744837000	6.889017000	-0.867352000
C	7.648044000	5.103243000	-0.518567000
C	8.157715000	4.367445000	-1.633954000
C	7.681700000	3.090405000	-1.516320000
C	6.819100000	3.070911000	-0.369688000
C	6.045380000	1.964964000	0.047143000
C	6.382778000	0.635373000	-0.435434000
H	6.797125000	0.550144000	-1.438881000
Fe	6.675227000	-4.628960000	-2.100827000
O	8.937215000	3.131110000	4.755056000
N	7.958450000	-3.152526000	-1.768546000
N	7.884114000	-5.347666000	-3.509170000
N	5.742293000	-6.381648000	-2.096689000
N	5.848840000	-4.176700000	-0.356054000
C	7.729792000	-2.037771000	-1.003473000
C	8.876557000	-1.171567000	-1.033787000
C	9.804100000	-1.773721000	-1.840150000
C	9.206009000	-2.978726000	-2.329828000
C	9.756810000	-3.779287000	-3.322375000
H	10.732027000	-3.498822000	-3.716123000
C	9.095482000	-4.844771000	-3.919701000
C	9.552798000	-5.536635000	-5.091396000
C	8.582793000	-6.445100000	-5.415266000
C	7.566458000	-6.340421000	-4.406802000
C	6.489278000	-7.209528000	-4.280151000
H	6.340221000	-7.959507000	-5.054501000
C	5.685276000	-7.266820000	-3.148309000
C	4.770461000	-8.333590000	-2.853956000
C	4.305361000	-8.113994000	-1.586990000
C	4.895676000	-6.884655000	-1.138910000
C	4.591567000	-6.253547000	0.059588000
H	3.907636000	-6.756218000	0.740802000
C	5.003311000	-4.969836000	0.391569000
C	4.492958000	-4.233945000	1.506577000

C	4.968466000	-2.956736000	1.388745000
C	5.831499000	-2.937202000	0.242438000
C	6.605187000	-1.831154000	-0.174155000
C	6.267626000	-0.501604000	0.308464000
H	5.853319000	-0.416415000	1.311929000
Cl	4.058646000	-3.101801000	-3.461539000
O	5.542673000	-3.644912000	-3.448746000
O	4.083216000	-1.792482000	-2.793007000
O	3.214673000	-4.068306000	-2.746789000
O	3.714580000	-2.997843000	-4.882496000
H	10.487765000	-5.334534000	-5.606791000
H	8.564901000	-7.148214000	-6.243386000
H	4.541873000	-9.157447000	-3.524341000
H	3.606257000	-8.713751000	-1.010780000
H	3.827233000	-4.634448000	2.265939000
H	4.773105000	-2.125460000	2.056667000
H	10.805771000	-1.430755000	-2.084101000
H	8.986049000	-0.263259000	-0.450881000
H	8.823340000	4.767878000	-2.393441000
H	7.876424000	2.259243000	-2.184572000
H	9.047709000	8.845792000	0.884808000
H	8.111965000	9.289782000	3.398285000
H	4.086994000	7.282929000	6.116184000
H	2.163537000	5.469924000	5.479436000
H	1.845081000	1.565325000	1.957819000
H	3.664465000	0.397324000	0.324615000

Structure 1^{2A}-perchlorate {5/2}

Fe	6.177746000	4.714226000	2.239822000
Cl	8.785312000	3.268512000	3.576031000
N	4.779658000	3.208095000	1.836268000
N	4.757499000	5.575159000	3.516280000
N	6.919588000	6.657564000	2.014634000
N	6.895587000	4.293509000	0.318630000
O	7.322082000	3.916728000	3.605314000
O	8.653159000	1.994452000	2.861389000
O	9.661781000	4.215478000	2.880812000
C	4.976683000	2.128495000	1.023870000
C	3.835265000	1.247617000	1.090887000
C	2.955613000	1.809553000	1.976979000
C	3.564434000	3.018636000	2.456217000
C	3.028314000	3.838560000	3.450562000
H	2.083266000	3.517820000	3.887972000
C	3.596353000	5.005012000	3.969400000
C	3.061591000	5.774039000	5.063518000
C	3.926796000	6.813927000	5.274044000
C	4.966456000	6.692614000	4.284337000
C	5.974464000	7.634859000	4.054660000
H	6.019519000	8.485911000	4.733479000
C	6.849876000	7.645135000	2.965349000
C	7.722493000	8.735694000	2.610499000
C	8.291837000	8.407678000	1.410080000
C	7.788856000	7.104953000	1.055829000
C	8.156609000	6.379364000	-0.080084000
H	8.864245000	6.855970000	-0.757663000
C	7.759194000	5.083515000	-0.409592000
C	8.265047000	4.345289000	-1.531443000
C	7.740303000	3.084545000	-1.446891000
C	6.871618000	3.069653000	-0.296373000
C	6.077456000	1.965980000	0.132945000
C	6.393146000	0.656707000	-0.404227000
H	6.814651000	0.614571000	-1.406876000
Fe	6.473628000	-4.580468000	-2.366784000
O	9.127752000	3.100448000	4.987031000
N	7.871788000	-3.074442000	-1.963102000
N	7.893954000	-5.441481000	-3.643107000
N	5.731790000	-6.523832000	-2.141526000
N	5.755934000	-4.159846000	-0.445471000
C	7.674736000	-1.994800000	-1.150769000
C	8.816162000	-1.113931000	-1.217766000
C	9.695865000	-1.675934000	-2.103768000
C	9.087051000	-2.885017000	-2.583000000
C	9.623211000	-3.704968000	-3.577310000
H	10.568296000	-3.384260000	-4.014655000
C	9.055155000	-4.871396000	-4.096168000
C	9.589912000	-5.640433000	-5.190281000
C	8.724655000	-6.680267000	-5.400859000
C	7.684956000	-6.558905000	-4.411198000

C	6.676890000	-7.501100000	-4.181572000
H	6.631805000	-8.352134000	-4.860412000
C	5.801485000	-7.511381000	-3.092253000
C	4.928935000	-8.601989000	-2.737368000
C	4.359642000	-8.274010000	-1.536916000
C	4.862613000	-6.971278000	-1.182667000
C	4.494954000	-6.245726000	-0.046704000
H	3.787381000	-6.722352000	0.630927000
C	4.892422000	-4.949895000	0.282820000
C	4.386696000	-4.211173000	1.404767000
C	4.911372000	-2.950958000	1.320179000
C	5.779918000	-2.936013000	0.169563000
C	6.573971000	-1.832283000	-0.259824000
C	6.258245000	-0.523019000	0.277307000
H	5.836698000	-0.480884000	1.279941000
Cl	3.866579000	-3.134674000	-3.703384000
O	5.329230000	-3.784186000	-3.732938000
O	4.000010000	-1.860551000	-2.989091000
O	2.989522000	-4.080733000	-3.007662000
O	3.523856000	-2.966677000	-5.114319000
H	10.505103000	-5.410611000	-5.729518000
H	8.795358000	-7.472538000	-6.141393000
H	4.790129000	-9.508496000	-3.320453000
H	3.656887000	-8.856246000	-0.946872000
H	3.707056000	-4.600712000	2.158129000
H	4.736095000	-2.134420000	2.011740000
H	10.679221000	-1.311426000	-2.388580000
H	8.965356000	-0.226693000	-0.611793000
H	8.944811000	4.734217000	-2.284721000
H	7.915662000	2.267977000	-2.138394000
H	8.994646000	8.989883000	0.820068000
H	7.861313000	9.642200000	3.193583000
H	3.856075000	7.606204000	6.014570000
H	2.146433000	5.544174000	5.602792000
H	1.972288000	1.445007000	2.261850000
H	3.686053000	0.360390000	0.484901000

Structure 1¹-perchlorate {3/2}

Fe	5.725202000	4.389216000	1.824139000
C	4.231356000	2.159397000	0.478368000
C	2.898889000	1.588970000	0.342635000
C	2.087518000	2.302861000	1.212734000
C	2.934471000	3.255649000	1.878568000
C	2.567136000	3.974746000	3.009240000
H	1.564788000	3.815442000	3.394888000
C	3.413534000	4.799677000	3.737446000
C	3.098382000	5.393040000	5.017488000
C	4.226462000	6.092514000	5.405770000
C	5.178207000	5.952437000	4.326625000
C	6.376844000	6.648222000	4.233919000
H	6.671861000	7.265843000	5.07515000
C	7.147671000	6.712233000	3.080417000
C	8.203556000	7.671194000	2.849616000
C	8.574689000	7.526385000	1.525078000
C	7.790641000	6.429448000	1.004233000
C	7.954916000	5.862330000	-0.251448000
H	8.672035000	6.326846000	-0.920863000
C	7.393714000	4.656504000	-0.657212000
C	7.828171000	3.920834000	-1.813301000
C	7.225773000	2.675469000	-1.745372000
C	6.351789000	2.712064000	-0.582087000
C	5.396423000	1.741009000	-0.210680000
C	2.396863000	0.615745000	-0.690989000
H	1.548743000	0.056286000	-0.269274000
H	3.138589000	-0.141738000	-0.954134000
C	1.946294000	1.295391000	-1.993433000
H	1.639166000	0.533473000	-2.722461000
H	2.764951000	1.873390000	-2.440776000
H	1.104073000	1.978775000	-1.827618000
C	0.612793000	2.153527000	1.448595000
H	0.427458000	2.062239000	2.531782000
H	0.271481000	1.203677000	1.015452000
C	-0.252317000	3.293608000	0.891768000
H	-1.313393000	3.113675000	1.117269000
H	-0.148389000	3.376961000	-0.197455000
H	0.026886000	4.263278000	1.324253000
C	1.796566000	5.243450000	5.748619000

H	4.519433000	-8.945526000	-4.962874000	H	0.715015000	0.746337000	1.644062000
H	3.074788000	-9.230363000	-4.014461000	C	-0.064933000	2.709175000	1.205231000
C	2.848204000	-7.679872000	-5.503550000	H	-1.091277000	2.448351000	1.501537000
H	2.504576000	-8.370016000	-6.287633000	H	0.005268000	2.618425000	0.113827000
H	1.964462000	-7.218448000	-5.044404000	H	0.104377000	3.763845000	1.459709000
H	3.422141000	-6.874432000	-5.979467000	C	1.604742000	5.634421000	5.594446000
C	2.627490000	-8.132242000	-1.401112000	H	1.654697000	5.989194000	6.633927000
H	2.518661000	-9.128924000	-1.853899000	H	1.321815000	4.572055000	5.662208000
H	2.879460000	-8.319085000	-0.345769000	C	0.495699000	6.404052000	4.861652000
C	1.279405000	-7.400819000	-1.478057000	H	-0.469964000	6.262504000	5.368294000
H	0.502365000	-7.971791000	-0.949347000	H	0.385900000	6.065793000	3.822730000
H	1.337367000	-6.401598000	-1.027489000	H	0.709664000	7.480544000	4.835798000
H	0.956473000	-7.271228000	-2.518811000	C	4.066903000	7.555520000	6.479348000
C	3.655222000	-4.592386000	2.538579000	H	5.070117000	7.531372000	6.932311000
H	3.741800000	-5.688220000	2.586870000	H	3.382322000	7.225772000	7.274541000
H	3.958909000	-4.234043000	3.532405000	C	3.720975000	9.002109000	6.096211000
C	2.187697000	-4.207495000	2.298161000	H	3.801870000	9.661792000	6.972344000
H	1.543890000	-4.639819000	3.077914000	H	2.696083000	9.077279000	5.710242000
H	2.055354000	-3.117686000	2.315543000	H	4.394478000	9.386383000	5.318580000
H	1.830812000	-4.564756000	1.323331000	C	8.786205000	8.898948000	4.150139000
C	5.187259000	-1.830845000	2.632815000	H	7.900657000	9.415070000	4.553491000
H	5.231162000	-0.802467000	2.260273000	H	9.368337000	9.677237000	3.635675000
H	4.211436000	-1.917985000	3.131306000	C	9.617165000	8.340825000	5.315344000
C	6.296248000	-2.041756000	3.674517000	H	9.887108000	9.145384000	6.014683000
H	6.230801000	-1.277131000	4.459907000	H	10.544762000	7.878488000	4.954109000
H	6.221912000	-3.032370000	4.143955000	H	9.066122000	7.572310000	5.873236000
H	7.292000000	-1.963529000	3.221433000	C	10.085304000	8.223403000	1.255170000
C	6.666908000	-0.360741000	0.324120000	H	10.178697000	9.256272000	1.621401000
H	7.053973000	0.060544000	1.254216000	H	9.890119000	8.314019000	0.175194000
O	5.901862000	-2.930120000	-3.277915000	C	11.423026000	7.498620000	1.466928000
O	3.470245000	-3.180074000	-2.974097000	H	12.230798000	8.019277000	0.932387000
Cl	4.496461000	-2.733258000	-3.931453000	H	11.382870000	6.463812000	1.102627000
O	4.400474000	-1.287575000	-4.195258000	H	11.689730000	7.460508000	2.530893000
O	4.464751000	-3.520368000	-5.173114000	C	9.168207000	4.501933000	-2.543553000
O	6.638138000	2.951120000	3.087599000	H	9.120051000	5.600073000	-2.596617000
O	9.082304000	3.194858000	2.913299000	H	8.886238000	4.151819000	-3.546736000
Cl	8.005929000	2.756232000	3.817752000	C	10.613715000	4.070306000	-2.254652000
O	7.974470000	3.549539000	5.055473000	H	11.297380000	4.481088000	-3.011865000
O	8.081223000	1.311658000	4.092993000	H	10.710634000	2.976623000	-2.268647000
Fe	6.769112000	-4.416243000	-2.110781000	H	10.949796000	4.416307000	-1.268162000

Structure ¹²-perchlorate {5/2}

Fe	6.015306000	4.357920000	2.201511000	H	5.520754000	0.015778000	-1.392903000
C	4.491945000	2.114503000	0.732685000	N	4.402933000	3.202560000	1.566507000
C	3.225312000	1.388488000	0.724617000	N	4.713882000	5.358652000	3.498525000
C	2.382745000	2.077363000	1.581778000	N	7.159588000	6.087967000	2.259668000
C	3.151478000	3.171761000	2.128853000	N	6.786884000	3.972706000	0.310601000
C	2.712961000	3.999829000	3.164032000	N	8.161862000	-3.157530000	-1.706620000
H	1.708909000	3.809088000	3.532648000	N	7.854551000	-5.272118000	-3.681528000
C	3.433980000	4.996303000	3.823303000	N	5.421772000	-6.043218000	-2.445411000
C	2.963436000	5.753028000	4.968570000	N	5.782264000	-3.957549000	-0.463739000
C	4.010274000	6.575958000	5.343889000	C	8.070092000	-2.086401000	-0.851951000
C	5.080007000	6.326597000	4.396565000	C	9.337453000	-1.362259000	-0.822266000
C	6.288209000	7.025277000	4.342454000	C	10.183443000	-2.034817000	-1.689072000
H	6.462851000	7.760694000	5.122885000	C	9.415529000	-3.115967000	-2.263439000
C	7.238885000	6.954044000	3.322189000	C	9.854144000	-3.918731000	-3.318247000
C	8.355631000	7.861633000	3.156114000	H	10.857991000	-3.719095000	-3.682754000
C	8.913119000	7.567295000	1.923249000	C	9.132317000	-4.898553000	-4.001540000
C	8.150983000	6.457536000	1.387091000	C	9.599868000	-5.624301000	-5.167839000
C	8.385953000	5.831567000	0.162414000	C	8.553557000	-6.440298000	-5.559823000
H	9.181501000	6.249286000	-0.448366000	C	7.487447000	-6.218778000	-4.601577000
C	7.768270000	4.682694000	-0.334982000	C	6.283034000	-6.925172000	-4.556298000
C	8.164908000	4.000543000	-1.544498000	H	6.106831000	-7.642276000	-5.353280000
C	7.463284000	2.807977000	-1.577768000	C	5.340434000	-6.885621000	-3.526620000
C	6.601355000	2.812535000	-0.400056000	C	4.232096000	-7.805659000	-3.371560000
C	5.642475000	1.825278000	-0.048308000	C	3.682762000	-7.543180000	-2.127892000
C	2.825650000	0.226121000	-0.137235000	C	4.439257000	-6.437927000	-1.574203000
H	2.001745000	-0.310571000	0.354932000	C	4.202263000	-5.833809000	-0.338789000
H	3.640382000	-0.502204000	-0.208360000	H	3.412579000	-6.268748000	0.267572000
C	2.373396000	0.619236000	-1.551289000	C	4.807359000	-4.684193000	0.172732000
H	2.129160000	-0.278864000	-2.133385000	C	4.402555000	-4.018386000	1.388930000
H	3.159522000	1.160697000	-2.091772000	C	5.092233000	-2.819118000	1.435573000
H	1.486892000	1.266029000	-1.522768000	C	5.957237000	-2.804178000	0.260492000
C	0.945677000	1.788453000	1.904986000	C	6.914095000	-1.809554000	-0.073960000
H	0.796443000	1.854561000	2.994893000				

H	-1.525751000	4.962730000	-1.813402000
C	-2.351040000	3.460153000	-0.500729000
H	-2.754207000	2.851625000	-1.322977000
H	-1.385645000	3.029729000	-0.204533000
H	-3.031021000	3.366179000	0.356450000
C	-6.729182000	5.325352000	2.027728000
H	-6.168148000	4.523146000	1.521876000
H	-7.458113000	4.811871000	2.670190000
C	-7.487651000	6.151723000	0.978266000
H	-8.179811000	5.510904000	0.413635000
H	-8.069331000	6.954245000	1.449794000
H	-6.802928000	6.623476000	0.261316000
C	-7.110880000	6.192864000	5.131123000
H	-7.565036000	5.239005000	4.825404000
H	-6.725879000	6.016319000	6.147444000
C	-8.203004000	7.271469000	5.183145000
H	-8.994263000	6.979634000	5.888711000
H	-7.798508000	8.240880000	5.501473000
H	-8.662104000	7.420611000	4.197751000
C	-4.250656000	9.407627000	8.507630000
H	-4.457545000	8.334218000	8.632749000
H	-3.625880000	9.689184000	9.365946000
C	-5.568894000	10.194103000	8.580803000
H	-6.095039000	9.974141000	9.520978000
H	-5.386273000	11.276121000	8.541807000
H	-6.237261000	9.941268000	7.747054000
C	-1.937533000	11.563031000	7.981394000
H	-1.476472000	12.425433000	7.488326000
H	-2.715800000	11.975116000	8.640536000
C	-0.871022000	10.864574000	8.840477000
H	-0.445829000	11.576619000	9.560163000
H	-1.286191000	10.020140000	9.405726000
H	-0.055999000	10.473265000	8.217809000
C	-1.306745000	12.679369000	4.800574000
H	-0.513817000	13.187902000	4.261024000
O	-0.175603000	16.225989000	7.509596000
C	0.724569000	15.916603000	8.348983000
C	0.440781000	15.431762000	9.687025000
O	-1.767208000	16.089488000	9.833456000
N	-0.943682000	15.233577000	10.126888000
C	2.148935000	15.959611000	8.070624000
N	2.634923000	16.233911000	6.716421000
O	2.024791000	15.719444000	5.785314000
O	3.653368000	16.915663000	6.605704000
C	3.128712000	15.707147000	9.017634000
H	4.178775000	15.813994000	8.755743000
C	2.763303000	15.279550000	10.294853000
C	1.416628000	15.100529000	10.613428000
H	1.133012000	14.717039000	11.590722000
O	-1.178655000	14.219933000	10.787344000
N	3.790489000	14.989923000	11.286565000
O	3.418019000	14.612892000	12.397649000
O	4.965063000	15.142744000	10.950625000
O	-3.178138000	10.029240000	2.084074000
C	-3.914970000	10.241204000	1.071152000
C	-3.408783000	10.271230000	-0.286544000
O	-1.252120000	10.910567000	0.197755000
N	-1.963493000	10.227098000	-0.529844000
C	-5.349842000	10.433548000	1.142095000
N	-6.014754000	10.557077000	2.440521000
O	-7.157366000	10.107901000	2.538391000
O	-5.405520000	11.133739000	3.335059000
C	-6.164293000	10.532509000	0.024146000
H	-7.239348000	10.643921000	0.143195000
C	-5.598745000	10.496613000	-1.250789000
C	-4.216817000	10.362047000	-1.406801000
H	-3.777730000	10.340076000	-2.401584000
O	-1.570681000	9.540363000	-1.471622000
N	-6.453429000	10.607985000	-2.426579000
O	-5.909896000	10.565361000	-3.530255000
O	-7.663806000	10.732981000	-2.241091000